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Discussion paper

Multinationals, tax competition and outside options

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Multinationals, tax competition and outside options.*

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Abstract

We analyse tax competition when a multinational firm has invested in two countries but also has an outside option, e.g., towards a third country. An interesting finding is that more attractive outside options for firms may constitute a win-win situation; the firm as well as its present host countries may gain when this occurs. The reason that it benefits the host countries is that an enhanced outside option reduces the inefficiencies of tax competition. An implication of the result is that better outside options for multinational firms may reduce the gains from host countries' policy coordination and thus reduce those countries' incentives to coordinate their policies. Also, with a development where outside options become more accessible, the perceived costs of tax competition, e.g., in terms of underprovision of public goods, may be overestimated. Our findings may also have implications for international negotiations, since it provides an argument for mutual reduction of entry barriers, as this may improve outside options.

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1 Introduction

Lower barriers to entry and developments in world capital markets have increased the actual and potential mobility of multinational enterprises (MNEs). This poses challenges for host countries' tax and regulation policies. For a number of countries, such as, for example, the member countries of the European Union, the policy challenge is two-faceted. First, they are facing competition from other similar (e.g. EU member) countries, where national governments try to attract new corporate investments.¹ Second, many MNEs have attractive investment and localisation options in entirely different countries (outside the EU-area), e.g., in low cost countries. As global developments make such outside options more accessible and attractive for MNEs, how will host countries react? What will be the implications for their tax policies, for the MNEs' investment decisions and for host countries' welfare? In this paper we address these issues. An interesting finding is that more attractive outside options for MNEs may constitute a win-win situation; the MNE as well as its present host countries may gain when this occurs. The reason is that a more attractive outside option for the firm (in the sense of being more attractive for all types and particularly so for highly efficient types of the firm²), may affect the strategic tax competition between its present host countries in such a way that a Pareto improvement is brought about. In such cases the enhanced outside option enforces a reduction in the investment distortions induced by tax competition between the host countries.

In line with the complex characteristics of most multinational firms,³ we assume that such a firm has better information than the governments about its efficiency.⁴ Possessing private information about efficiency, the MNE has incentives to undertake strategic in-

¹In general, foreign direct investments have been rapidly increasing (see Markusen (1995)), and recent empirical research show that effective tax rates are important factors for determining the localisation decisions of multinational enterprises (see, e.g., Devereux and Freeman (1995)).

²See Section 6.2 for the precise definition.

³According to Markusen (1995), multinationals tend to be important in industries and firms that are characterised by: high levels of R&D relative to sales, a large share of professional and technical workers in their workforce, products that are new or technically complex, and high levels of product differentiation and advertising.

⁴The international nature of an MNE and the high number of interfirm transactions make it hard for authorities to observe its true income and costs. Complex technology also implies obstacles for authorities to ascertain the firm's efficiency, and thereby derive its true operating profits. Many of the inputs are not standard commodities with established market prices, making it difficult to monitor costs or impose norm prices.

vestments. On the one hand, to receive favorable treatment in terms of taxation, the firm may like to be conceived as a low-productivity type in the EU-countries. But it would also like to indicate that it is highly mobile, i.e., unless operating conditions in the EU-area are sufficiently favorable, it may reschedule investments or migrate altogether to another region where net costs are lower. To signal a credible threat of relocation, the firm would like to be conceived as having a high reservation profit, i.e., a high productivity on alternative investments. However, under the reasonable assumption that the firm's productivities inside and outside the EU-area are positively correlated, the firm cannot at the same time indicate a low and a high productivity. So the firm has countervailing incentives vis-a-vis each government, but may still pitch governments against each other.

We model this setting as a common agency; the firm relates to several principals (governments) but has in addition an outside option. Previous papers on tax competition have also considered an outside option for the firm, but have assumed the option to be the same for all types, and hence typically normalized to zero. What is different here is that it is larger than zero and type dependent. The paper thus analyses the combined effects of countervailing incentives (see Lewis and Sappington (1989), Maggi and Rodríguez-Clare (1995), Jullien (2000)) and common agency (Martimort (1992), Stole (1992), Martimort and Stole (2002, 2009)). Multiprincipal problems with countervailing incentives have previously been studied by Mezzetti (1997), but in a different and complementary setting.⁵ There is by now a considerable literature analysing tax and regulatory competition in various settings, see Gresik (2001) for a general survey and Bond and Gresik (1996), Olsen and Osmundsen (2001, 2003), Laffont and Pouyet (2004) and Calzolari (2001, 2004) for analyses in common agency frameworks. The novel feature considered here is the strategic implications of better outside options for firms, and in particular of outside options that are relatively more attractive for very efficient firms.

In several parts of the world countries work to coordinate and harmonize their tax policies. The EU is a prominent example. We analyse the effects of such measures by comparing outcomes for cooperating and competing countries, respectively. We show that

⁵In Mezzetti (1997) the agent has private information about his *relative* productivity in the tasks he performs for two principals. With this informational assumption Mezzetti obtains a case of countervailing incentives and contract complements. In our model the agent has private information about his *absolute* efficiency level, the relevant actions are contract substitutes, and the presence of countervailing incentives is due to an outside option. The two models yield different implications; e.g. whereas Mezzetti obtains equilibria with pooling for a range of intermediate types, we obtain fully separating equilibria.

with the presence of an outside option, tax competition - relative to coordination - may entail lower investments for inefficient firms and higher investments for efficient ones, and that the firm's profits may be lower or higher when the countries compete than when they cooperate. Whether the firm is better or worse off under policy competition relative to policy coordination, depends among other things on investment substitution possibilities and its ownership structure. The firm is better off under a cooperative relative to a competitive regime when the elasticity of substitution is low, or if owner shares held by residents of the cooperating countries are large. And as already mentioned, we also show that a higher outside option for the firm may actually be beneficial for the firm's host countries when they are engaged in tax competition with each other. This means that better outside options for the firm may reduce the gains from policy coordination and thus reduce host countries' incentives to coordinate their policies.

In common agency models (e.g. Bond and Gresik, 1996)⁶ it has been shown that tax competition (rather than cooperation) may make both governments and firms worse off. In other tax competition models a similar result may emerge, typically in cases where tax competition leads to overtaxation (Huizinga and Nielsen, 1997).⁷ Given this, the main contribution of this paper is to show that an improvement of the outside option may reduce the inefficiencies of tax competition.

The intuition for our finding that the two competing countries can be better off if the type-dependent outside option increases (in the sense that it is larger for any type and relatively more so for the most efficient types), is that although a better outside option makes the participation constraint more difficult to be met for national authorities, the larger outside option becomes a more stringent disciplining device for the authorities, and hence limits the negative externalities they mutually exert. When the countries coordinate instead, the countries' welfare is reduced by a larger outside option – as expected.

Our finding implies that, with a development where outside options become more accessible, the perceived costs of tax competition, e.g., in terms of underprovision of public goods, may be overestimated. Another implication is that our findings may offer another argument against protectionism, as the mutual opening up of the economy is likely to

⁶Models where two governments choose trade taxes to regulate a multinational firm with private cost information.

⁷A two-period model under symmetric information where a country may levy source- and residence-based capital income taxes and where part of the firm may be owned by foreigners.

enhance the firms' outside options.

2 The model

The MNE invests K_1 in country 1 and K_2 in country 2,⁸ yielding profits (before joint costs and taxes) $N_1(K_1, \theta)$ and $N_2(K_2, \theta)$, where θ is an efficiency parameter. The MNE also has an option of investing in another economic area. To simplify we assume that if the MNE exercises this option, it moves all its operations to this region.⁹ We further assume that it is not optimal for the MNE to make all its investments only in country 1 or only in country 2.¹⁰ There are several examples that may motivate this assumption. First, consider a vertically integrated MNE which is located in two EU-countries (e.g., coal mining and natural gas extraction). Extraction levels exceed local demand, and excess output is exported to the neighbouring country, due to high transportation costs. Such a firm cannot credibly threaten to concentrate all its activities in only one of the countries. The outside option of the firm may be to extract natural resources and serve customers in another region. The second case is an MNE (e.g., in the food industry), that is presently located in two EU-countries.¹¹ The MNE is likely to maintain some activity in both countries due to irreversible investments that have been made in production facilities. Even without the presence of fixed factors, the firm may want to be present in both of the countries in order to be close to the customers and thus closely observe changing consumer patterns.¹² A third explanation for localisation in several countries is that the MNE is a multi-product firm, e.g., a producer of household appliances or semi-conductors, and that the countries differ with respect to the presence of industrial clusters for different types

⁸In addition there may be sunk investments in both countries.

⁹Given a passive government in the outside region, this assumption mainly serves to simplify notation. An alternative setup would be to assume that the MNE in equilibrium actually invests in a third country, in which case the outside option would be to reschedule a larger fraction of its activities to this country. This alternative approach would generate the same qualitative results..

¹⁰We thus assume intrinsic common agency. Calzolari and Scarpa (2008) and Martimort and Stole (2009) analyse both intrinsic and delegated agency, but assume a type-independent outside option. As a first step for the type dependent case, we limit the analysis to intrinsic common agency.

¹¹The division of investments may have historical explanations, e.g., that the output is sold to consumers in both countries and that there used to be large transportation costs or other trade barriers.

¹²This is important for products characterised by local variations in taste, and where product development, design and fashion are important. The food and furniture industries are examples.

of products.¹³ Lower trade costs may open up the possibility to locate in low cost or low tax regions, i.e., outside options may emerge.

Let Π and π denote, respectively, the pre- and post-tax global profits of the firm:

$$\Pi(K_1, K_2, \theta) = N_1(K_1, \theta) + N_2(K_2, \theta) - C(K), \quad (1)$$

$$\pi = \Pi - r_1 - r_2, \quad (2)$$

where $K = K_1 + K_2$, $C(K)$ denotes joint costs for the two affiliates and r_1 and r_2 are the taxes paid to the two countries.¹⁴ We assume that $C'(K) > 0$, $C''(K) > 0$. The convex costs $C(K)$ imply economic interaction effects among the two affiliates; an increase in the investments in one of the countries implies a higher marginal joint cost, which again affects the investments of the other country. These joint costs may have different interpretations. First, K may represent scarce human capital, e.g., management resources or technical personnel, where we assume that the MNE faces convex recruitment and training costs. Second, K may represent real investments, where $C(K)$ are management and monitoring costs of the MNE. Economic management and co-ordination often become more demanding as the scale of international operations increase, i.e., $C(K)$ is likely to be convex. Third, instead of interpreting $C(K)$ as joint costs, it may in the case of imperfect competition be perceived as measuring interaction effects in terms of market power. For example, if the two affiliates sell their output on the same market (e.g., in a third country), their activities are substitutes: high investments (and output) in affiliate 1 reduce the price obtained by affiliate 2. Another example of a market interaction effect is a case where K_1 and K_2 are investments in R&D; the marginal payoff on R&D-activities of affiliate 1 is lower the higher is the R&D activity of affiliate 2, e.g., due to a patent race.¹⁵

The countries compete to attract scarce real investments from the MNE, and the interaction of the principals is through the MNE's joint costs. Note that $\frac{\partial^2 \Pi}{\partial K_1 \partial K_2} = -C''(K) < 0$, e.g., we address a case of contracting substitutes. The affiliates of the MNE are separate and independent entities, which means that they are subsidiaries and thus taxed at source.

¹³An example of a firm with such a dispersed manufacturing structure is Phillips. The value of the MNE may be closely linked to its business strategy of supplying multiple products. If this is common knowledge, a threat to become a niche producer that is located in only one country would not be credible.

¹⁴Nothing substantial would change by using a more general (convex) cost function $C(K_1, K_2)$, with $\partial^2 C / \partial K_1 \partial K_2 > 0$.

¹⁵Olsen (1993) analyses single-principal regulation of independent R&D units, and emphasizes the role of research activities as substitutes.

The firm has private information about θ and net operating profits in the two countries. It is presumed that if the firm is efficient in one country it is also an efficient operator in the other country; for reasons of tractability we assume that the firm has the same efficiency in the two countries. Efficiency types are distributed according to the cumulative distribution function $F(\theta)$ with density $f(\theta)$ having the support $[\underline{\theta}, \bar{\theta}]$, where $\underline{\theta}$ denotes the least and $\bar{\theta}$ the most efficient type. Efficient types have higher net operating profits than less efficient types, both on average and at the margin: $\frac{\partial N_j}{\partial \theta}(K_j, \theta) > 0$ and $\frac{\partial^2 N_j}{\partial \theta \partial K_j}(K_j, \theta) > 0$, $j = 1, 2$; where the latter inequality is a single crossing condition.

The MNE and the governments are risk neutral. For all efficiency types the affiliate's net operating profits in each country are sufficiently high so that both governments always want to induce the domestic affiliate to make some investments in their home country. Domestic consumer surpluses in the two countries are unaffected by changes in the MNE's production level, since the firm is assumed to be a price taker (or its market is outside the two countries). The governments have utilitarian objective functions: the social domestic welfare generated by the MNE is a weighted sum of the domestic taxes paid by the firm and the firm's global profits:

$$W_j = (1 + \lambda_j)r_j + \alpha_j\pi, \quad j = 1, 2,$$

where λ_j is the general equilibrium shadow cost of public funds in country j , and α_j is the owner share of country j in the MNE. The shadow costs of public funds are taken as exogenously given in our partial analysis. We have $\lambda_j > 0$, $j = 1, 2$, since marginal public expenditure is financed by distortive taxes. By inserting for Eq.(1), the social welfare function for country 1 can be restated as

$$W_1 = (1 + \lambda_1) (\Pi(K_1, K_2, \theta) - r_2) - (1 + \lambda_1 - \alpha_1)\pi. \quad (3)$$

The MNE has an additional localisation alternative: it has an option to move all its activity outside the EU area, e.g., to a low cost country or to a tax haven. This investment option would produce an after tax profit of $n(\theta)$, i.e., the firm has private information about the alternative return on its scarce resources. Assuming that firms that have high returns in the EU area also have high returns on outside options, we have $n'(\theta) > 0$. We consider here the case where the participation constraint is binding for some type(s) other than the least productive one, i.e., for some type $\theta \neq \underline{\theta}$. In these cases there are typically countervailing incentives, where low-productivity types are tempted to claim to have high

productivity in order to secure themselves high rents. To illustrate these effects, and yet have a fairly simple model, we confine ourselves to cases where the participation constraint is binding only for the least productive and the most productive type, i.e., only for $\theta = \underline{\theta}$ and $\theta = \bar{\theta}$. This will occur, for example, if the outside returns function $n(\theta)$ is 'sufficiently convex', in a sense to be made precise below.

3 A simple case

To illustrate the forces at play in a simple setting, we consider first a case with independent investments ($\frac{\partial^2 \Pi}{\partial K_1 \partial K_2} = 0$), two symmetric countries and the firm being entirely owned by residents in those countries (so $\alpha_1 + \alpha_2 = 1$). To have a particularly simple cooperative benchmark, we will also at first assume zero shadow costs of public funds ($\lambda_j = 0$).¹⁶ This assumption implies that if the countries cooperate there is no motive to introduce distortive taxation, since the cooperative welfare in this case is $W_1 + W_2 = \Pi(K_1, K_2, \theta)$. Any rents (pure profits) obtained by the firm accrue in the end to domestic residents in the two countries, and since such rents are not costly by assumption, taxation should be non-distortive. Investments will then be first-best, maximizing the firm's global profits $\Pi(K_1, K_2, \theta)$. This outcome will prevail independently of the firm's options outside the two countries.

Operating non-cooperatively, however, each country has a motive to extract rents from the firm. This follows because rents accruing to foreign residents reduce domestic welfare; see (3). This "equity externality" leads to distortive taxation in each country in the non-cooperative setting, and hence to reduced welfare compared with the cooperative case. The distortions follow from each country's usual trade-off between rent extraction and production efficiency under asymmetric information.¹⁷ But now the form and extent of these distortions will depend on the firm's options outside the two countries. To induce the firm to stay in the region, its rents cannot be reduced too much. And in particular, if the most efficient types of MNEs have very attractive outside options compared to less efficient types, the most efficient types cannot be taxed too harshly. It turns out that this limitation on the countries' ability to tax the most efficient types leads, under some

¹⁶While unrealistic, the assumption simplifies intuitive explanations for the results, and is made here for that reason only.

¹⁷Given independent investments, the firm will adjust its investments independently in the two countries, and hence each country's trade off is essentially that of a single principal in this case.

conditions, to reduced overall distortions in the non-cooperative taxation regime. Hence we can conclude in those cases that better outside options (for the most efficient types of MNEs) will lead to improved welfare, and hence constitute a win-win situation for the parties involved. By crowding back distortionary taxation, the enhanced outside option is beneficial for both the government and the firm's owners. It dampens tax competition and by that reduces the extent of underinvestment and improves welfare.

It is important to note that the type dependency of the outside option is crucial in this argument. If all efficiency types of firms faced the same outside option, then a change of this option would not affect the tax induced investment distortions in the two countries. Each country would in such a case optimally react by adjusting the lump-sum element of its tax scheme so that all types' rents were adjusted to the new outside level. The trade-offs between rent extraction and production efficiency would not be affected, and hence the distortive elements of the tax schemes would also remain unaffected. Investments and hence welfare would thus not be affected by a change of such a type independent outside option.

With type dependency, however, there are countervailing incentives that affect the trade off between rent extraction and production efficiency for each country, and these incentives are crucially influenced by how the outside option varies with types. It is through this link that variations in the outside options for the most efficient relative to the least efficient types will have repercussions for the tax induced distortions in the two countries, and hence for the two countries' welfare.

To see this in some detail, let $R_j(K_j)$ denote the taxes that the firm pays to government j , based on the firm's investments in country j . (The following analysis is heuristic, since a stringent analysis for the more general case is given in later sections.) For multinationals, profits are not observable to the tax authorities, due to among other things strategic transfer pricing. Taxes are therefore made contingent on investments, which are assumed here to be the key verifiable variables for such a firm.¹⁸ The assumption $\frac{\partial^2 \Pi}{\partial K_1 \partial K_2} = 0$ implies that the firm's investments in the two countries are now independent and given by $\frac{\partial \Pi}{\partial K_j} = R'_j(K_j)$. Moreover, the firm's equilibrium profits (rents) satisfy (by e.g. the

¹⁸Profits may be less difficult to verify for purely domestic firms, and different tax schemes may thus be introduced for purely domestic and for multinational firms, reflecting the poorer information available for the latter.

envelope property)

$$\pi'(\theta) = \frac{\partial \Pi}{\partial \theta}(K_1(\theta), K_2(\theta), \theta) \quad (4)$$

Acting non-cooperatively, each country chooses its tax scheme to maximize domestic expected welfare EW_j , subject to incentive compatibility (IC), represented by (4), and participation (IR) constraints ($\pi(\theta) \geq n(\theta)$, all θ), taking the tax scheme of the other country as given. A comprehensive analysis of this problem has been given by Jullien (2000) for the single-principal case. Since investments in the two countries are here independent, his results apply for each of the two principals. (See later sections for the more general case.)

Moreover, throughout the paper we confine ourselves to the case of outside option functions $n(\theta)$ that leave the IR constraints non-binding for interior types. There will then be at most one type (say $\check{\theta}_j$) where the IC constraint is non-binding in the sense that the countervailing incentives exactly balance; i.e. the temptation to claim low θ to indicate low productivity is for this type just balanced by the temptation to claim high θ to indicate favorable outside options. From Julien's analysis it now follows that the best-response tax scheme for each country is characterized by investments that satisfy

$$\frac{\partial \Pi}{\partial K_j} - (1 - \alpha_j) \frac{\partial^2 \Pi}{\partial K_j \partial \theta} \frac{F(\check{\theta}_j) - F(\theta)}{f(\theta)} = 0. \quad (5)$$

To interpret this equation, note that a tax induced higher investment dK_j by type θ will affect country j 's welfare $W_j = \Pi(K_j, K_i, \theta) - R_i(K_i) - (1 - \alpha_j)\pi$ partly by its effect on the firm's pre-tax profits Π and partly by its effect on rents π . The two terms in (5) capture these effects. (By the independence assumption invoked here, foreign investments and tax payments will not be affected.) For efficiency types θ below type $\check{\theta}_j$ incentive constraints are binding downwards: the incentive to claim low productivity dominates the incentive to claim high outside options. A higher investment by such a type of firm will tighten incentive constraints for more efficient types (types in the range $(\theta, \check{\theta}_j)$), and this is costly in terms of increased rents to such firms. The second term in (5) accounts for these welfare costs.¹⁹

When type $\check{\theta}_j$ coincides with the most efficient one ($\check{\theta}_j = \bar{\theta}$) - the conventional case - there is a welfare cost for all types except $\bar{\theta}$. Equilibrium investments are then lower than their first-best levels. If on the other hand $\check{\theta}_j < \bar{\theta}$, the second term in (5) is negative for $\theta > \check{\theta}_j$, so the welfare effect associated with the firm's rents is positive. For such

¹⁹From (4) the rent differential $\pi'(\theta)d\theta$ increases by $\frac{\partial^2 \Pi}{\partial K_j \partial \theta} d\theta$, and the same increase must be given to all types in $(\theta, \check{\theta}_j)$, hence to a fraction $F(\check{\theta}_j) - F(\theta)$ of all types.

types the incentive constraints are binding upwards; the firm is tempted to mimic a more efficient type in order to make it appear that it has a higher outside option. By inducing such a firm to invest more, and thereby increase its "internal" profits, $\pi(\theta)$, the incentive constraints for firms with lower efficiency (types in the range $(\check{\theta}_j, \theta)$) are relaxed. This leads to overinvestments relative to the first-best solution for these types.

We have $\check{\theta}_j < \bar{\theta}$, and hence overinvestments for high-efficiency types $\theta > \check{\theta}_j$, when the participation constraint for the most efficient type is binding ($\pi(\bar{\theta}) = n(\bar{\theta})$). Variations in the outside profit for the most efficient type (keeping the outside profit for the least efficient type fixed) will thus affect $\check{\theta}_j$ and hence affect investment distortions, see (5).²⁰ It is through this link that variations in this outside profit have repercussions for equilibrium investments and welfare.

Suppose now that the participation constraint for the most efficient type is 'just binding' in the sense that $\check{\theta}_j = \bar{\theta}$ initially, but any higher outside profit for this type ($\Delta n(\bar{\theta}) > 0$) yields countervailing incentives and $\check{\theta}_j < \bar{\theta}$. Then there are underinvestments for all types initially (when $\check{\theta}_j = \bar{\theta}$ and so $\frac{\partial \Pi}{\partial K_j} > 0$ for all $\theta < \bar{\theta}$), but higher investments for the most efficient types after a change involving higher outside profits for type $\bar{\theta}$ (and by continuity of $n(\theta)$ for types nearby $\bar{\theta}$). After the change we have countervailing incentives with a new $\check{\theta}'_j < \bar{\theta}$, and hence certainly higher investments for all types $\theta > \check{\theta}'_j$, but also higher investments than initially for a range of intermediate types (for θ in some interval $(\theta', \check{\theta}'_j)$). On the margin, these investment increases are beneficial for welfare, since investments were too low initially.

In later sections, we identify conditions under which these types of adjustments, induced by the countries' non-cooperative tax responses to better outside options for the most efficient types of firms, lead to improvements in each country's expected welfare. We then allow for substitution possibilities in production ($\frac{\partial^2 \Pi}{\partial K_1 \partial K_2} < 0$), non-EU foreign ownership ($\alpha_1 + \alpha_2 < 1$) and non-zero costs of public funds ($\lambda_j > 0$). The analytical advantage of assuming zero marginal costs of public funds is of course that the basis for welfare comparisons becomes very simple, namely the first-best allocation, independent of outside options. However, in such a case the only reason to tax corporations is to extract rents from residents in the other country. In reality, the marginal cost of public

²⁰More precisely, it is variations in the outside profit difference $n(\bar{\theta}) - n(\underline{\theta})$ for the most and least efficient types that affect $\check{\theta}_j$ and hence affect investments, see Section 6. We consider variations that allows $n(\theta) - n(\underline{\theta})$ to increase for all $\theta > \underline{\theta}$.

funds is positive, and the government has additional motives for rent extraction. Welfare comparisons are then more challenging, as the basis for comparisons (cooperative welfare in the two countries) also changes when the level of the outside option changes. The level of underinvestment may be reduced to some extent (generating higher welfare), but at the same time the firm gets to keep more of the rent (which reduces welfare).

Thus, other things equal, the higher is the cost of leaving rents to the firm, the less likely it is that an enhanced outside option is welfare improving. Available estimates of the marginal cost of public funds are, however, fairly small; see Snow and Warren (1996).²¹ But also, in our setting other things are not equal, since the tax equilibrium depends on the magnitude of the marginal cost of public funds. In our model we find for the case of no substitution possibilities that enhanced outside options for the firm are always welfare improving (over some range), but that the positive welfare effect is lower, the higher is the marginal cost of public funds (see Proposition 6).

Another complexity of welfare comparisons arises when we allow for substitution possibilities in production ($\frac{\partial^2 \Pi}{\partial K_1 \partial K_2} < 0$). The substitution possibilities imply that tax competition will involve strategic elements where one country's adjustment of domestic taxes induce investment responses in the other country. Each country will then try to expand its tax base at the expense of the other, i.e., we have a case of fiscal externalities. It turns out that these strategic elements dampen the positive welfare effects identified above. The underlying reason for this is that the 'equity externality effect' discussed in this section and the strategic effects induced by substitution possibilities tend to have opposite effects on equilibrium investments.²²

We find (for a class of parametric specifications) that better outside options for the most efficient types of the firm leads to improved welfare when the shadow costs of public funds are relatively small, the substitution possibilities are limited, and ownership by residents of the two countries ($\alpha_1 + \alpha_2$) is relatively large. More precisely this holds when, for $\lambda_1 = \lambda_2$ we have $\frac{\alpha_1 + \alpha_2}{1 + \lambda} > \Psi$, where $\Psi < 1$ is a number positively related to the

²¹The opportunity cost of an additional dollar of tax revenue includes the marginal welfare cost caused by the increase in distortionary taxation. Estimates of marginal welfare cost of public funds have varied widely. An overview and analysis of estimates is given by Snow and Warren (1996). From their Table 1 we can infer that 0.2 is a reasonable estimate.

²²See Section 5 below. Olsen and Osmundsen (2001) analysed these effects for the type-independent outside option case.

elasticity of substitution in production (see Proposition 6).²³ For a numerical illustration, it may be noted that for $\lambda_1 = \lambda_2 = 0.2$ and $\alpha_1 = \alpha_2 = 0.5$ the condition holds if the elasticity of substitution (σ) is less than 3.5; see the discussion following Proposition 5.

If σ is sufficiently high, an enhanced outside option will reduce welfare, as the induced effect on equilibrium investments is either negative for welfare, or if positive dominated by the negative welfare effect of increased rents to the firm. For $\sigma = 0$ it is only the equity externalities that generate a deviation between cooperative and non-cooperative equilibrium, and an enhanced outside option will then (in some range) always move the equilibrium towards higher welfare by reducing the negative impacts of the equity externalities. For a given outside option, substitution ($\sigma > 0$) will cause strategic effects (fiscal externalities) that counteract the equity externalities. In fact, for a certain level of σ (the level corresponding to $\frac{\alpha_1 + \alpha_2}{1 + \lambda} = \Psi(\sigma)$) the two types of externalities will neutralize each other, so that cooperative and non-cooperative equilibria will be equal. An enhanced outside option will then not generate any positive welfare effects. For σ higher than this level, enhanced outside options will always reduce welfare. But as we have seen, for reasonable parameter values this critical level of σ tends to be quite high.

4 Cooperating countries

To have a benchmark, consider the case where the two countries cooperatively design their tax policies. The countries (principals) then seek to maximise the cooperative welfare given by $W = W_1 + W_2$ (we assume $\lambda_1 = \lambda_2$) subject to incentive compatibility (IC) and participation (IR) constraints for the firm. Incentive compatibility requires that the firm's equilibrium profits (rents) satisfy (4).²⁴ This first-order condition (4) together with $K'_j(\theta) \geq 0, j = 1, 2$ are sufficient for incentive compatibility.²⁵ Since the principals cooperate and act as a single one, we have from Julien (2000) the following result.

²³It turns out that this is exactly the condition that leads to the kind of equilibrium investment responses considered in this section, where non-cooperative investments exceed cooperative investments for the most efficient types.

²⁴To interpret this condition here, note that if type $\theta + d\theta$ mimics the less efficient type θ (by investing $K_j(\theta)$ instead of $K_j(\theta + d\theta)$), it obtains additional profits $\Pi(K(\theta), \theta + d\theta) - \Pi(K(\theta), \theta)$ relative to type θ in country j . To avoid such behavior the principal must allow for this rent differential in the tax scheme.

²⁵Monotonicity of $K_j(\theta)$ is typically ensured by assuming that $F(\theta)$ has a monotone hazard rate.

Proposition 1 Suppose there is a $\check{\theta} \in [\underline{\theta}, \bar{\theta}]$ such that $K_1(\theta), K_2(\theta)$ given by

$$(K_1(\theta), K_2(\theta)) = \arg \max_{K_1, K_2} \left[\Pi(K_1, K_2, \theta) - \left(1 - \frac{\alpha_1 + \alpha_2}{1 + \lambda}\right) \frac{\partial \Pi}{\partial \theta}(K_1, K_2, \theta) \frac{F(\check{\theta}) - F(\theta)}{f(\theta)} \right]$$

are increasing ($K'_j(\theta) \geq 0$). Suppose further that the associated rent $\pi(\theta)$ given by (4), i.e., $\pi(\theta') = \int_{\underline{\theta}}^{\theta'} \frac{\partial \Pi}{\partial \theta}(K_1(\theta), K_2(\theta), \theta) d\theta + \pi(\underline{\theta})$, satisfies $\pi(\theta) \geq n(\theta)$ and

(a) $\pi(\underline{\theta}) = n(\underline{\theta})$ if $\check{\theta} = \bar{\theta}$.

(b) $\pi(\underline{\theta}) = n(\underline{\theta})$ and $\pi(\bar{\theta}) = n(\bar{\theta})$ if $\underline{\theta} < \check{\theta} < \bar{\theta}$.

(c) $\pi(\bar{\theta}) = n(\bar{\theta})$ if $\check{\theta} = \underline{\theta}$.

Then $(K_1(\theta), K_2(\theta))$ together with the associated rent $\pi(\theta)$ is the optimal solution.

Note that the first order conditions for optimal investments take the form (double subscripts denote second-order partials)

$$(1 + \lambda) \frac{\partial \Pi}{\partial K_j} - (1 + \lambda - \alpha_1 - \alpha_2) \Pi_{\theta j} \frac{F(\check{\theta}) - F(\theta)}{f(\theta)} = 0. \quad (6)$$

This is similar to condition (5) above, and similar interpretations apply. The cases (a)-(c) represent cases where the participation constraints are binding (a) only for the least efficient type, (b) for the least and for the most efficient types, and (c) only for the most efficient type.

5 Non-cooperative equilibrium

Consider now the case where the governments of the two countries compete (to attract the firm's investments) rather than cooperate. In this case the MNE relates to each government separately. The governments cannot credibly share information and they act non-cooperatively. In the present context it is natural to consider equilibria in tax functions.²⁶ Let, as in Section 3, $R_j(K_j)$ denote the taxes that the firm pays to government j , based on the firm's investments in country j . We say that a pair $K_1(\theta), K_2(\theta)$ of investment profiles is commonly implementable if there are tax schedules $R_j(K_j)$, one for each principal, such that for every type θ the firm's profits are maximal for this pair of investments.

Lemma 2 In any differentiable equilibrium where IR-constraints are binding only for types $\underline{\theta}, \bar{\theta}$ we have: There exists $\check{\theta}_1, \check{\theta}_2 \in [\underline{\theta}, \bar{\theta}]$ such that equilibrium investments and profits

²⁶Under mild conditions this is not restrictive, see Martimort and Stole (2002).

satisfy

$$\Pi_{i\theta} K'_i \geq -\Pi_{12} K'_1 K'_2, i = 1, 2 \quad \text{and} \quad K'_1 K'_2 (\Pi_{1\theta} \Pi_{2\theta} + \Pi_{12} [\Pi_{1\theta} K'_1 + \Pi_{2\theta} K'_2]) \geq 0 \quad (7)$$

$$\frac{\partial \Pi}{\partial K_j} = \frac{1 + \lambda - \alpha_j}{1 + \lambda} \left[\Pi_{\theta j} + \Pi_{\theta i} \frac{\Pi_{ij} K'_i(\theta)}{\Pi_{\theta i} + \Pi_{ij} K'_j(\theta)} \right] \frac{F(\check{\theta}_j) - F(\theta)}{f(\theta)}. \quad (8)$$

and

$$\int_{\underline{\theta}}^{\theta} \frac{\partial \Pi}{\partial \theta} (K_j(\theta'), K_i(\theta'), \theta') d\theta' + \pi(\underline{\theta}) \geq n(\theta), \quad \text{all } \theta, \text{ with equality for } \theta = \underline{\theta}, \bar{\theta}. \quad (9)$$

Condition (7) is a well known necessary condition for common implementability, derived from the second-order conditions for the firm's maximization problem (see e.g. Stole (1992)). Except for the parameters $(\check{\theta}_1, \check{\theta}_2)$, the conditions (8) are analogous to the equilibrium conditions derived by Stole (1992) and others for the conventional case where the outside value is type independent. The conventional case corresponds to $\check{\theta}_1 = \check{\theta}_2 = \bar{\theta}$.

To understand condition (8) note that the terms on the LHS represent the marginal effect of increased K_j on country j 's surplus (adjusted by factor $1 + \lambda$). The term on the RHS represents the marginal effects on rents (also adjusted by factor $1 + \lambda$). This term has itself two components; the first is the conventional (direct) one, just like in the cooperative case; the second is a strategic effect, working through the change in foreign investments (say $\frac{\partial \hat{K}_i}{\partial K_j}$) induced by the change in domestic investments. The foreign investment \hat{K}_i is given by $\frac{\partial \Pi}{\partial K_i}(K_j, \hat{K}_i, \theta) = R'_i$ and hence satisfies $(R''_i - \Pi_{ii}) \frac{\partial \hat{K}_i}{\partial K_j} = \Pi_{ij}$. In equilibrium the first-order condition for \hat{K}_i holds as an identity in θ , and by differentiating this identity we obtain $\frac{\partial \hat{K}_i}{\partial K_j} = \frac{\Pi_{ij} K'_i(\theta)}{\Pi_{\theta i} + \Pi_{ij} K'_j(\theta)}$. This explains the formula (8). If investments are substitutes, increasing in both countries, and commonly implementable, the strategic effect will be negative.

Apart from the strategic effect, conditions (8) and (6) also differ in the way that condition (8) involves country-specific parameters $\check{\theta}_j$ and only domestic owner shares (α_j) . The latter reflects an equity externality; country j doesn't internalize the implications of its policy for the firm's foreign owners. This makes country j more aggressive with respect to extracting rents. The equity and strategic effects tend to have opposite effects on equilibrium investments.

To derive sufficient conditions for an equilibrium we confine ourselves to quadratic versions (approximations) for the relevant functions and a uniform distribution over types. Then we have:

Proposition 3 *Suppose countries are symmetric, θ is uniform and $\Pi()$ has constant second-order partials with $\Pi_{12} < 0$ (substitutes) and that $\Pi(K_1, K_2, \theta)$ is concave in K_1, K_2 . Then investments $K_1(\theta), K_2(\theta)$ is a differentiable equilibrium with IR-constraints binding only for types $\underline{\theta}, \bar{\theta}$ if and only if (7), (8) and (9) hold for some $\check{\theta}_j, \check{\theta}_i \in [\underline{\theta}, \bar{\theta}]$.*

6 Properties of equilibria

In this section we will analyse properties of equilibria for the model. The following parametrization will be used

$$N_j(K_j, \theta) = m\theta(K_j + h) + kK_j - \frac{1}{2}qK_j^2$$

$$C(K_1, K_2) = \frac{1}{2}a(K_1 + K_2)^2,$$

$$F(\theta) = \theta \text{ for } \theta \in [0, 1],$$

with $m, k, q, a > 0$. The assumption $q > 0$ guarantees concavity of Π . With this parametrization the second-order partials are

$$\Pi_{12} = -a, \quad \Pi_{jj} = -(q + a), \quad \Pi_{j\theta} = m.$$

As a reference point, the full information *first-best* solution is in this case given by $\frac{\partial \Pi}{\partial K_i} = 0$. This yields symmetric investment schedules that are linear in θ . The first-order conditions (6) for the cooperative case also yield linear and symmetric solutions, and these exhibit underinvestment for low types (possibly overinvestment for high types) compared to first-best investments.

6.1 Equilibrium investments and profits

In the non-cooperative setting; the equilibrium equations (8) have linear solutions, say of the form $K_j(\theta) = L_j + K'_j\theta$, $j = 1, 2$, see the appendix. The slopes of the equilibrium schedules are seen to be independent of $\check{\theta}_1, \check{\theta}_2$, and therefore the same as in the case of a type-independent outside option. For symmetric countries (where $\alpha_1 = \alpha_2$) they are also symmetric, so $K'_1 = K'_2 = K'$. While the slopes K'_j of the equilibrium schedules are uniquely determined (and equal), the intercepts L_j (or equivalently the parameters $\check{\theta}_1, \check{\theta}_2$) are not unique and not necessarily equal, even when countries are symmetric.²⁷ But the Pareto-preferred equilibrium is the symmetric one, and we will concentrate on

²⁷In the (intrinsic) common agency framework we consider here, the equilibrium doesn't pin down the way that the countries divide between themselves the burden of providing rents for the firm, and this implies that equilibrium investments are not uniquely pinned down either.

that equilibrium in the following.

Proposition 4 *(i) The slopes K'_j of the equilibrium investment schedules given in Proposition 3 are unique (and equal if the countries are symmetrical), but the intercepts of these linear schedules are generally not unique. (ii) Equilibrium profits $\pi(\theta)$ are uniquely determined. (iii) For symmetric countries the equilibrium with the highest total expected welfare is the symmetric one.*

We now turn to a comparison of resource allocations under the cooperative and the non-cooperative regimes. In the following we assume that the Pareto-preferred symmetric equilibrium is chosen under non-cooperation. We also assume that the outside value $n(\theta)$ for the firm is such that participation constraints are binding only for the least efficient and/or most efficient types.

Proposition 5 *There is a critical number $\Psi < 1$, ($\Psi = 1/(1 + \frac{q}{4a})$, $\frac{q}{a} = \frac{\Pi_{11}}{\Pi_{12}} - 1$), such that for $\frac{\alpha_1 + \alpha_2}{1 + \lambda} > \Psi$ we have: The firm's profits are for all types $\theta \in (\underline{\theta}, \bar{\theta})$ lower when the countries compete than when they cooperate. Hence, the IR constraint for the most efficient type $\bar{\theta}$ is either (i) binding in both regimes, (ii) binding only in the competitive regime, or (iii) non-binding for both regimes. Investments are in case (iii) lower for all types (but type $\bar{\theta}$) under competition compared to cooperation. In cases (i) and (ii), investments under competition are lower for inefficient types (all $\theta < \tilde{\theta}$, some $\tilde{\theta} < \bar{\theta}$) and higher for efficient types ($\theta > \tilde{\theta}$) compared to investments under cooperation.*

For $\frac{\alpha_1 + \alpha_2}{1 + \lambda} < \Psi$ the converse conclusions hold.

The proposition implies that the firm's profits are lower in the competitive regime when the 'inside' owner share $\alpha_1 + \alpha_2$ is large. This result parallels that given in Olsen and Osmundsen (2001) for the case of a constant (type-independent) outside option. When inside owner shares are large the equity externalities are large, and this leads to more aggressive rent extraction when countries compete compared to when they cooperate.

The type-dependent outside option yields however quite different implications for equilibrium investments. For a constant outside option, the more aggressive rent extraction associated with large equity externalities leads to equilibrium investments (under competition) that are for all types *lower* than investments under cooperation. This is covered by case (iii) in the proposition. But when outside options are type-dependent, and the most efficient types have sufficiently better outside options than less efficient types (cases (i) and

(ii)), equilibrium investments are for the more efficient types *higher than investments under cooperation*. The more aggressive rent extraction associated with large equity externalities leads in this case to larger investments for high types and lower investments for low types.

The conditions in the proposition can be related to the ease with which capital can be substituted between the two countries. The elasticity of substitution between K_1 and K_2 for the firm's symmetric pre-tax profit function $\Pi(K_1, K_2, \theta)$, evaluated at the point $K_1 = K_2 = \frac{1}{2}K_F(\theta)$, where $K_F(\theta)$ is the first-best investment in each country, is $\sigma = \frac{2a}{q} + 1$.²⁸ In view of this, the last proposition says that the firm's rents tend to be lower under competition compared to cooperation when the elasticity of substitution is 'small'.²⁹ Thus, it is when substitution is not too easy ($\frac{a}{q}$ small) that the firm tends to be worse off when the countries compete compared to when they cooperate.

6.2 Implications of better outside options

We now consider comparative statics effects of variations in the outside value for the firm. This analysis is complicated by the fact that the equilibrium in principle depends on the whole profile of outside values (over all types), and hence that the exercise in general should involve comparisons of all such profiles. We limit ourselves to profiles that generate the type of equilibrium studied above, i.e. where the participation constraints are binding only for the most efficient and least efficient types. We will show that if $n^1(\theta)$ and $n^2(\theta)$ are two such profiles, and $n^1(\theta) \geq n^2(\theta)$, then under competition it may well be the case that the higher profile $n^1(\theta)$ yields a greater social surplus than the lower profile $n^2(\theta)$. Hence all parties may gain when the firm's outside option becomes more favorable. This will *not* occur when the countries cooperate, since the higher profile implies a stricter set of participation constraints and therefore if anything a lower total surplus.

All else equal (technology, demand, owner shares etc.) an equilibrium of the form studied in this paper is determined by the outside option values for the most efficient and the least efficient types of the firm, or more precisely by the difference $n(\bar{\theta}) - n(\underline{\theta})$. This single number, which we will denote by η , determines how the equilibrium depends on the outside value profile. Normalizing $n(\underline{\theta}) = 0$, we have $\eta = n(\bar{\theta})$. Such an equilibrium is only feasible for η in some range (η_1, η_2) . The lower bound η_1 of this range is the rent that

²⁸For the quadratic (and symmetric) functional form we find, for symmetric investments; $\sigma = \frac{q+2a}{q} \left(\frac{K_F(\theta)}{K_j} - 1 \right)$, where $K_F(\theta) = \frac{m\theta+k}{q+2a}$.

²⁹For $\alpha_1 = \alpha_2 = .5$ the condition is $\lambda < \frac{q}{4a}$, i.e. $\sigma < 1 + \frac{1}{2\lambda}$, hence $\sigma < 3.5$ for $\lambda = .2$.

would accrue to the best type in the conventional case with type-independent reservation profit. This corresponds to the case $\check{\theta}_1 = \check{\theta}_2 = \bar{\theta}$ in our model. The upper bound η_2 is the profit that would accrue to the best type if on the other hand $\check{\theta}_1 = \check{\theta}_2 = \underline{\theta}$.

For η in this range, the firm's equilibrium profit is unique and given by a convex function $\pi(\theta; \eta)$. Here η is used as an indexing parameter; we have $\pi(\bar{\theta}; \eta) = \eta$. Note that any outside value profile that satisfies $n(\underline{\theta}) = \pi(\underline{\theta}; \eta) = 0$, $n(\bar{\theta}) = \pi(\bar{\theta}; \eta) = \eta$, and $n(\theta) \leq \pi(\theta; \eta)$, will generate such an equilibrium. Let $N(\eta)$ denote the family of all such profiles. Formally

Definition. For η in (η_1, η_2) , let $N(\eta)$ be the family of all outside value profiles that satisfy $n(\underline{\theta}) = 0$, $n(\bar{\theta}) = \eta$ and $n(\theta) \leq \pi(\theta; \eta)$, where $\pi(\theta; \eta)$ is (uniquely) given by $\pi(\theta; \eta) = \int_{\underline{\theta}}^{\theta} \frac{\partial \Pi}{\partial \theta'} (K_1(\theta'), K_2(\theta'), \theta') d\theta'$, $\pi(\bar{\theta}; \eta) = \eta$, and $K_j(\theta)$, $j = 1, 2$ satisfy (8) and (9) with $\check{\theta}_j \in (\underline{\theta}, \bar{\theta})$, $j = 1, 2$.

We will study how the equilibrium outcome associated with an outside value profile in the family $N(\eta)$ varies when η varies on the interval (η_1, η_2) . Each profile in $N(\eta)$ yields equilibrium profits $\pi(\theta; \eta)$, and this function is increasing in η . A more favorable outside option, in the sense of one that yields an outside value that is higher for the best type and that belongs to the corresponding family $N(\eta)$, will thus lead to equilibrium profits that are more favorable for every type of firm.

Proposition 6 For $\frac{\alpha_1 + \alpha_2}{1 + \lambda} > \Psi$ (respectively $\frac{\alpha_1 + \alpha_2}{1 + \lambda} < \Psi$), where $\Psi = 1/(1 + \frac{q}{4a}) < 1$, we have: For the family $N(\eta)$ it is the case that, as η (the outside value for the best type) increases on (η_1, η_2) , the total welfare $E(W_1 + W_2)$ associated with the symmetric non-cooperative equilibrium first increases and then decreases (respectively decreases over the whole interval). In any case, every type of firm benefits as η increases. The marginal welfare effect $(\frac{\partial}{\partial \eta} E(W_1 + W_2)_{\eta=\eta_1})$ is smaller, the larger is the cost of public funds and the larger is the elasticity of substitution.

The proposition shows that the total surplus under competition is either (i) first increasing and then decreasing, or (ii) monotone decreasing in the firm's outside value index η . More favorable outside opportunities for the firm will thus in a set of cases improve the social surplus, although only up to some point. But the improvement may be considerable; the efficiency loss relative to the first-best outcome may be reduced by as much as 75% when the outside value increases this way.³⁰

³⁰This reduction is obtained for $\alpha_1 + \alpha_2 = 1$ and $\lambda = 0$; proof available from the authors.

Note also that the condition that defines case (i) ($\frac{\alpha_1 + \alpha_2}{1 + \lambda} > \Psi$), is the same condition that makes the competitive tax regime less attractive for the firm than the cooperative regime. This is thus the case where domestic owner shares are relatively large, the cost of public funds is relatively small, and substitution of investments is not too easy for the firm. Since the surplus under cooperation will if anything decline as η increases, we see that the relative performance of the competitive regime will then improve as the firm's outside opportunities become better. The total benefits of cooperation will thus become smaller when the most efficient types of MNEs get more attractive outside opportunities (e.g. in third-country tax havens), and the incentives to cooperate will diminish in such cases.

We have in Section 3 provided some intuition for the result. When domestic owner shares are large and substitution of investments is not too easy for the firm ($\frac{\alpha_1 + \alpha_2}{1 + \lambda} > \Psi$), the equilibrium responses to better outside options for the most efficient types of firms entail investments that for those firms become higher relative to investments under cooperation. This is beneficial when there are underinvestments compared to the cooperative levels initially.

7 Conclusion

We analyse a case where an MNE allocates investments between two countries (the home region), while also having an outside investment option, e.g. a low cost region or a tax haven. The two countries in the home region compete to attract the firm's investments and to extract rents from the firm. The ability to tax and regulate the MNE is limited by private information, e.g. facilitated by a large number of transfer prices for services provided among various affiliates of the MNE. The firm has private information about its efficiency and net operating profits in the two countries, and about the value of the outside investment option. It has an incentive to report a low productivity in the home region, and at the same time overstating its productivity on outside investments (exaggerating the value of its outside option). However, the productivity in the home region and the foreign region are likely to be correlated. Thus, the MNE faces countervailing incentives: it cannot at the same time claim to be efficient and inefficient.

A higher value of the outside option is beneficial for the firm, and detrimental to the governments if they cooperate. However, if the countries compete they may well

be positively affected by higher outside options. Enhanced outside options for the most efficient types of firms, e.g. due to reduced entry barriers in other regions for such firms, may actually benefit the home governments and represent a Pareto improvement for those countries and the firm. In such situations a development towards improved outside options for firms will reduce the incentives for governments to cooperate.

We have assumed that the firm has private information about its operating profits and about its efficiency level, whereas the investment levels are assumed to be subject to symmetric information. Observability of investments may be a reasonable description for physical capital, but not to the same extent for intangible assets. The latter may be important for MNEs, since they typically have high levels of R&D relative to sales.³¹ Also, we assume that the MNE's efficiency levels are perfectly correlated in the countries of operation. Uncorrelated efficiency parameters, however, may be relevant if firms invest in different countries in order to diversify portfolios. Asymmetric information about investment levels, or uncorrelated information parameters, may represent interesting extensions of the present model. Each of these extensions would imply a multidimensional screening problem, which is typically hard to solve even in a single-principal setting; see e.g. Rochet and Chone (1998). But Rochet and Stole (2002) analyse a tractable model where the agent (a buyer) has private information about his type (his marginal willingness to pay) as well as his outside option, and these variables are not correlated. There is then no countervailing incentives, and monopoly pricing is shown to yield no distortion at the top as well as either no distortion at the bottom or bunching. For duopolists the outcome is shown to be generally qualitatively similar to the outcome under monopoly, except that under some conditions the outcome entails efficient quality allocations. Exploring the implications of this type of model for tax competition seems highly worthwhile.

Appendix

Proof of Lemma 2:

³¹Privately observed investments that are undertaken *after* the tax system is in place (moral hazard) can be accommodated in the model by interpreting the profit function as an indirect function where such investments are chosen optimally, conditional on the observable K_j 's. Privately observed investments in place *ex ante* would, however, be a part of the firm's (multidimensional) private information. The model can be interpreted as representing a case where the aggregate effect of several such variables on profits can be captured by a one-dimensional parameter.

Suppose principal i offers the tax schedule $R_i(K_i)$. Define

$$\hat{K}_i(K_j, \theta) = \arg \max_{K_i} [\Pi(K_j, K_i, \theta) - R_i(K_i)] \quad (10)$$

By incentive compatibility the agent's maximal profit must satisfy $\pi'(\theta) = \frac{\partial \Pi}{\partial \theta}(K_j(\theta), \hat{K}_i(K_j(\theta), \theta), \theta)$.

Principal j 's payoff is

$$EW_j = \int_{\underline{\theta}}^{\bar{\theta}} \left\{ (1 + \lambda) \left(\Pi(K_j(\theta), \hat{K}_i(K_j(\theta), \theta), \theta) - R_i(\hat{K}_i(K_j(\theta), \theta)) \right) - (1 + \lambda - \alpha_j) \pi(\theta) \right\} dF(\theta)$$

By assumption $K_j(\theta)$ maximizes this objective subject to the IC constraint and IR-constraints for the two end-types. Letting $\Lambda_j = \frac{1 + \lambda - \alpha_j}{1 + \lambda}$, the Hamiltonian for the problem is

$$\begin{aligned} H(K_j, \pi, \theta, p) &= \left\{ \Pi(K_j, \hat{K}_i(K_j, \theta), \theta) - R_i(\hat{K}_i(K_j, \theta)) - \Lambda_j \pi \right\} f(\theta) \\ &\quad + p \frac{\partial \Pi}{\partial \theta}(K_j, \hat{K}_i(K_j, \theta), \theta) \end{aligned} \quad (11)$$

The necessary conditions for an optimum include (Seierstad-Sydsæter 1987, Thm 5 p 185) $p'(\theta) = -\frac{\partial H}{\partial \pi} = \Lambda_j f(\theta)$, $p(\underline{\theta}) \leq 0$, $p(\bar{\theta}) \geq 0$. These conditions imply $p(\theta) = \Lambda_j (F(\theta) - c)$, $0 \leq c \leq 1$. So we may write

$$p(\theta) = \Lambda_j (F(\theta) - F(\check{\theta}_j)), \quad \text{some } \check{\theta}_j \in [\underline{\theta}, \bar{\theta}]$$

It is further necessary that $K_j(\theta)$ maximizes the Hamiltonian. The first-order condition for that is (using the envelope property for \hat{K}_i)

$$\Pi_j(K_j, \hat{K}_i(K_j, \theta), \theta) + \frac{p(\theta)}{f(\theta)} \left[\Pi_{j\theta}(K_j, \hat{K}_i(K_j, \theta), \theta) + \Pi_{i\theta}(K_j, \hat{K}_i(K_j, \theta), \theta) \frac{\partial \hat{K}_i}{\partial K_j} \right] = 0$$

In equilibrium we must have $\hat{K}_i(K_j(\theta), \theta) = K_i(\theta)$. From the definition of \hat{K}_i we can then derive an (equilibrium) expression for $\frac{\partial \hat{K}_i}{\partial K_j}$ (see the text following the lemma). Substituting this expression and the expression for $p(\theta)$ into the first-order condition above yields the formula (8). This completes the proof.

Proof of Proposition 3

It is well known that for the conventional case with type independent reservation utility (so $\check{\theta}_1 = \check{\theta}_2 = \bar{\theta}$) and contract substitutes ($\Pi_{12} < 0$) the system (8) has a unique solution

that satisfies the necessary conditions (7) for common implementability (Stole 1992, Martimort 1992). These necessary conditions for implementability are also sufficient in the case of quadratic functions and contract substitutes, provided both schedules $K_1(\theta), K_2(\theta)$ are nondecreasing. The same reasoning shows that for given $\check{\theta}_1, \check{\theta}_2 \in [\underline{\theta}, \bar{\theta}]$ the system (8) has a unique commonly implementable solution. For θ uniform (so $\frac{F(\theta) - F(\check{\theta}_j)}{f(\theta)}$ is linear) this solution has moreover schedules $K_1(\theta), K_2(\theta)$ that are linear in θ . From (8) we see (by symmetry) that the (constant) slopes are equal; $K'_1 = K'_2 = K'$. Moreover, we have (by symmetry and common implementability (7)) $0 \leq 2 \frac{-\Pi_{12}}{\Pi_{1\theta}} K' \leq 1$. (In fact it can be verified by explicit solution of (8) that both inequalities are strict when Π is strictly concave). Standard arguments then show that if $R_1(K_1), R_2(K_2)$ is a pair of tax schedules that implement the solution $K_1(\theta), K_2(\theta)$, then these schedules are mutual best responses, and hence an equilibrium of the taxation game.

Proof of Proposition 4

The equilibrium equations (8) now take the form:

$$m\theta + k - (q + a)K_j(\theta) - aK_i(\theta) = \frac{1 + \lambda - \alpha_j}{1 + \lambda} \left[m + \frac{maK'_i(\theta)}{aK'_j(\theta) - m} \right] (\check{\theta}_j - \theta), \quad (12)$$

where $i, j = 1, 2, i \neq j$. The system has linear solutions of the form $K_j(\theta) = L_j + K'_j\theta$, $j = 1, 2$. Equations (12) yield four equations for the six parameters that characterize the solutions, i.e., $(L_j, K'_j, \check{\theta}_j)$, $j = 1, 2$:

$$m - (q + a)K'_j - aK'_i = -\frac{1 + \lambda - \alpha_j}{1 + \lambda} \left[m + \frac{maK'_i}{aK'_j - m} \right], \quad (13)$$

$$k - (q + a)L_j - aL_i = \frac{1 + \lambda - \alpha_j}{1 + \lambda} \left[m + \frac{maK'_i}{aK'_j - m} \right] \check{\theta}_j, \quad (14)$$

The necessary implementability conditions (7) can be written, given $K'_j > 0$ as

$$0 \leq \frac{a}{m} K'_j \leq 1 \quad j = 1, 2 \quad \text{and} \quad \frac{a}{m} K'_1 + \frac{a}{m} K'_2 \leq 1. \quad (15)$$

The slopes of the equilibrium schedules are seen to be independent of $\check{\theta}_1, \check{\theta}_2$, and therefore the same as in the case of no outside option. For symmetric countries (where $\alpha_1 = \alpha_2$) they are also symmetric, so $K'_1 = K'_2 = K'$. An equilibrium as described in Proposition 3 must in addition satisfy $\pi(\bar{\theta}) = n(\bar{\theta})$ and $\pi(\underline{\theta}) = n(\underline{\theta})$, hence we must have $n(\bar{\theta}) - n(\underline{\theta}) = \int_{\underline{\theta}}^{\bar{\theta}} \frac{\partial \Pi}{\partial \theta} d\theta$,

i.e.,

$$n(\bar{\theta}) - n(\underline{\theta}) = \int_{\underline{\theta}}^{\bar{\theta}} \sum_{j=1}^2 m(L_j + K'\theta + h) d\theta = m[(L_1 + L_2) + 2h + K']. \quad (16)$$

While the slopes K'_j of the equilibrium schedules are uniquely determined (and equal) under the conditions given in the last proposition, we note that there are only three equations to determine the remaining four parameters that characterize the equilibrium investment schedules. Consider now an equilibrium solution $(L_j, K', \check{\theta}_j)$, $j = 1, 2$. According to (16), the solution must satisfy $L_1 + L_2 = M$, where M is a uniquely determined constant. We can then construct a new solution by letting the new intercepts satisfy this relation, and solve for the new $\check{\theta}_j$ -parameters from (12). (This is feasible, at least for small variations in the intercept parameters.) This proves the first part of the proposition.

To verify part (ii), note that we have $\Sigma_j K_j(\theta) = \Sigma_j (L_j + K'\theta)$ and that $\pi'(\theta) = \frac{\partial \Pi}{\partial \theta} = \Sigma_j m(L_j + K'\theta + h)$. Since the last sum is uniquely determined and $\pi(\underline{\theta})$ is given, we see that $\pi(\theta)$ is uniquely determined for all θ , as was to be shown.

To verify part (iii) note that total welfare is $W_1 + W_2 = (1 + \lambda)\Pi(K_1, K_2, \theta) - (1 + \lambda - \Sigma \alpha_j)\pi(\theta)$. Rents $\pi(\theta)$ are constant across the relevant equilibria. In these equilibria investments are of the form $K_1(\theta) = K(\theta) + \delta$, $K_2(\theta) = K(\theta) - \delta$. By symmetry and concavity of the objective $\Pi(K_1, K_2, \theta)$ it is maximal for $\delta = 0$. This completes the proof.

Proof of Proposition 5. (Sketch)

In the fully symmetric case one can easily solve for and compare the slope parameters (K'_{jC}, K'_j) of the investment schedules for the cooperative and the competitive regime, respectively. One finds that (as in Olsen and Osmundsen 2001) $K'_{jC} \leq K'_j$ iff $\frac{1+\lambda}{\alpha_1+\alpha_2} \leq \Psi^{-1} = \frac{q}{4a} + 1$. Consider the case $\frac{1+\lambda}{\alpha_1+\alpha_2} < \Psi^{-1}$. The investment schedule is then steeper in the competitive regime ($K'_{jC} < K'_j$). By considering the various possibilities for binding IR constraints, the results in the proposition then follow. The complementary case is handled similarly.

Proof of Proposition 6

Since the countries are symmetric with respect to technologies and owner shares, equations (13) admit unique solutions K'_j , with $K'_1 = K'_2$. For every η in (η_1, η_2) , and every outside value function in the family $N(\eta)$, there is a unique symmetric equilibrium of the form given in Proposition 4, with parameters $L_1 = L_2$ and $\check{\theta}_1 = \check{\theta}_2 \in (\underline{\theta}, \bar{\theta})$. From (14,16)

we see that these parameters are in fact linear functions of η ; with $L_j(\eta)$ strictly increasing and $\check{\theta}_j(\eta)$ strictly decreasing. The total value $E(W_1 + W_2)$ associated with this equilibrium can (after an integration by parts) be written as

$$(1 + \lambda) \int_{\underline{\theta}}^{\bar{\theta}} \left\{ \Pi(K_1, K_2, \theta) - \left(1 - \frac{\alpha_1 + \alpha_2}{1 + \lambda}\right) \frac{\partial \Pi}{\partial \theta}(K_1, K_2, \theta) \frac{F(\check{\theta}_1) - F(\theta)}{f(\theta)} \right\} dF(\theta) \\ - (1 + \lambda - \alpha_1 - \alpha_2) \left\{ \pi(\underline{\theta})F(\check{\theta}_1) + \pi(\bar{\theta})[1 - F(\check{\theta}_1)] \right\},$$

where $K_j = K_j(\theta; \eta) = L_j(\eta) + K'_j \theta$, $\check{\theta}_1 = \check{\theta}_1(\eta)$, $\pi(\underline{\theta}) = 0$ (by our normalization) and $\pi(\bar{\theta}) = \eta$. Note that the partial derivative of this expression wrt. $\check{\theta}_1$ is zero. Using the uniform distribution, the marginal effect on total expected welfare ($\frac{\partial}{\partial \eta} E(W_1 + W_2)$) can then be written as $(1 + \lambda)$ times the following expression

$$\int_{\underline{\theta}}^{\bar{\theta}} \sum_j \left\{ \frac{\partial \Pi}{\partial K_j} - \left(1 - \frac{\alpha_1 + \alpha_2}{1 + \lambda}\right) \frac{\partial^2 \Pi}{\partial K_j \partial \theta} (\check{\theta}_1 - \theta) \right\} \frac{\partial K_j}{\partial \eta} d\theta - \left(1 - \frac{\alpha_1 + \alpha_2}{1 + \lambda}\right) [1 - \check{\theta}_1].$$

Using (8,12) and symmetry we can write this as

$$\left[2\left(1 - \frac{\alpha_1}{1 + \lambda}\right) \left[m + \frac{maK'_1}{aK'_1 - m}\right] - \left(1 - \frac{2\alpha_1}{1 + \lambda}\right) 2m \right] \int_{\underline{\theta}}^{\bar{\theta}} (\check{\theta}_1 - \theta) d\theta \frac{\partial K_1}{\partial \eta} - \left(1 - \frac{2\alpha_1}{1 + \lambda}\right) [1 - \check{\theta}_1] \quad (17)$$

Note that $\eta = \eta_1$ yields $\check{\theta}_1 = \bar{\theta} = 1$, and hence

$$\frac{\partial}{\partial \eta} E(W_1 + W_2)_{\eta=\eta_1} = (1 + \lambda) \left[\left(1 - \frac{\alpha_1}{1 + \lambda}\right) \left[1 + \frac{aK'_1}{aK'_1 - m}\right] - \left(1 - \frac{2\alpha_1}{1 + \lambda}\right) \right] C \quad (18)$$

where $C = 2m \int_0^1 (1 - \theta) d\theta \frac{\partial K_1}{\partial \eta}$. From (16) we see that $\frac{\partial K_1}{\partial \eta} = \frac{\partial L_1}{\partial \eta} = \frac{1}{2m}$, so $C = \frac{1}{2}$.

Differentiating once more in (17) we obtain

$$\frac{\partial^2}{\partial \eta^2} \frac{E(W_1 + W_2)}{(1 + \lambda)} = \left\{ \left[\left(1 - \frac{\alpha_1}{1 + \lambda}\right) \left[1 + \frac{aK'_1}{aK'_1 - m}\right] - \left(1 - \frac{2\alpha_1}{1 + \lambda}\right) \right] + \left(1 - \frac{2\alpha_1}{1 + \lambda}\right) \right\} \frac{\partial \check{\theta}_1}{\partial \eta} < 0$$

where the inequality follows from (15) and $\frac{\partial \check{\theta}_1}{\partial \eta} < 0$. Hence the total value $E(W_1 + W_2)$ is strictly concave in η , and therefore increasing for some η if and only if $\frac{\partial}{\partial \eta} E(W_1 + W_2) > 0$ for $\eta = \eta_1$.

The equation (13) can be solved explicitly for K'_1 in this case. Doing so and substituting into (18) we find

$$\frac{\partial}{\partial \eta} E(W_1 + W_2)_{\eta=\eta_1} = (1 + \lambda) \left[1 + Q/2 - \sqrt{\gamma + \gamma^2 + Q^2/4} - \gamma \right] C, \quad (19)$$

where $Q = \frac{q}{a} + 1 > 1$ and $\gamma = 1 - \frac{\alpha_1}{1 + \lambda}$. The condition $\frac{\partial}{\partial \eta} E(W_1 + W_2)_{\eta=\eta_1} > 0$ then holds iff $1 + Q > \gamma(Q + 3)$. Substituting for γ and Q , the latter condition is equivalent to $\frac{\alpha_1}{1 + \lambda} > \frac{2}{4 + q/a}$. This is again equivalent to the condition stated in the proposition.

Finally note that for $\eta = \eta_2$ we have (by definition of η_2) $\check{\theta}_j = \underline{\theta} = 0$, and hence

$$\frac{\partial}{\partial \eta} \left[\frac{E(W_1 + W_2)}{(1 + \lambda)} \right]_{\eta=\eta_2} = \left[\left(1 - \frac{\alpha_1}{1 + \lambda}\right) \left[1 + \frac{aK'_1}{aK'_1 - m}\right] - \left(1 - \frac{2\alpha_1}{1 + \lambda}\right) \right] \left(-\frac{1}{2}\right) - \left(1 - \frac{2\alpha_1}{1 + \lambda}\right) < 0$$

This proves the first part of the proposition.

Finally consider the marginal welfare effect in (19). Differentiation shows that the expression in (19) is decreasing in λ and increasing in Q . Since $Q = \frac{q}{a} + 1$ is inversely related to the (point) elasticity of substitution $\sigma = \frac{2a}{q} + 1$, it follows that the marginal welfare effect in (19) is decreasing in λ and in σ . This completes the proof.

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